Am. J. Trop. Med. Hyg., 89(1), 2013, pp. 145–150
doi:10.4269/ajtmh.12-0750
Copyright © 2013 by The American Society of Tropical Medicine and Hygiene

Effectiveness of Rapid Transport of Victims and Community Health Education on Snake Bite Fatalities in Rural Nepal

Sanjib K. Sharma, Patrick Bovier, Nilambar Jha, Emilie Alirol, Louis Loutan, and François Chappuis*

Department of Medicine, and School of Public Health and Community Medicine, B. P. Koirala Institute of Health Sciences, Dharan, Nepal; Department of Community Medicine and Primary Care, and Division of International and Humanitarian Medicine, Geneva University Hospitals and University of Geneva, Geneva, Switzerland

Abstract. Snake bite is a major public problem in the rural tropics. In southern Nepal, most deaths caused by neurotoxic envenomation occur in the village or during transport to health centers. The effectiveness of victims' transport by motorcycle volunteers to a specialized treatment center, combined with community health education, was assessed in a non-randomized, single-arm, before-after study conducted in four villages (population = 62,127). The case-fatality rate of snake bite decreased from 10.5% in the pre-intervention period to 0.5% during the intervention (relative risk reduction = 0.949, 95% confidence interval = 0.695–0.999). The snake bite incidence decreased from 502 bites/100,000 population to 315 bites/100,000 population in the four villages (relative risk reduction = 0.373, 95% confidence interval = 0.245–0.48), but it remained constant in other villages. Simple educational messages and promotion of immediate and rapid transport of victims to a treatment center decreased the mortality rate and incidence of snake bite in southeastern Nepal. The impact of similar interventions should be assessed elsewhere.

INTRODUCTION

Venomous snake bites are an important public health hazard worldwide, particularly in tropical and subtropical countries. In Asia, estimates of snake bite incidence vary between 500,000 and four million annual cases with as many as 100,000 deaths.[1–3] Southern Asia is the world's most affected region because of its high population density, widespread agricultural activities, numerous snake species, and lack of functional snake bite control programs.[4,5]

With one-third of the population living below the poverty line, Nepal is among the poorest countries in the world. Up to 85% of Nepali people live in remote and difficult-to-access terrain, which contributes to poor access for health care facilities. The World Health Organization estimates that 20,000 persons are bitten by snakes each year in Nepal, resulting in > 1,000 deaths.[1] However, because most deaths occur in villages or during transport and are therefore not recorded in hospital statistics, the true public health impact of snake bites is likely to be much higher.[6–8] Most bites occur in the Terai, a lowland agricultural plain located in the southern region of Nepal and characterized by a hot tropical climate and high population density. Most bites occur during the rainy season (April–October), which corresponds to the peak in farming activities.[6,7]

Most severe cases of snake bites in Nepal are caused by elapid snakes, in particular the Indian spectacled cobra (*Naja naja*) and the common Indian krait (*Bungarus caeruleus*),[9,10] but other species of cobra and kraits are present. The venom of these snakes contains potent neurotoxins that specifically target the neuromuscular junction. Progressive descending paralysis is characteristic of elapid bite envenoming, and patients usually die from respiratory failure, once paralysis reaches the diaphragm and the inter-costal muscles.[11,12] Progression of envenoming signs can be extremely rapid, and respiratory failure has been observed as early as 30 minutes after a cobra bite.[13]

We previously conducted a community-based survey in five village development committees (VDCs) of eastern Terai in 2002 and found a high annual snake bite incidence (1,162 bites/100,000 population) and associated mortality (162 deaths/100,000 population). Several determinants of deaths were identified in this study: presence of sign(s) of envenoming, initial visit to a traditional healer, and lack of available transport. In contrast, rapid transfer to a snake bite treatment center and administration of antivenom were associated with decreased risk of death. In particular, the use of a motorcycle to transport the victim was strongly associated with survival.[8]

We therefore hypothesized that an intervention combining transport of victims by motorcycle and community-based health education could decrease snake bite mortality in Nepal. We tested this hypothesis in four VDCs and report the results of this interventional study.

MATERIALS AND METHODS

Study area and population. The study was conducted in the Terai region of eastern Nepal in four VDCs with known high incidence of snake bites: Chulachuli (population = 18,176), Kerabari (population = 15,668), Itahara (population = 15,561), and Rajghat (population = 12,722).[8,14] Each VDC is subdivided into several wards. The four VDCs are located 20–46 km from the Damak Red Cross Sub Center (RCSC), which is the referral snake bite treatment center for 47 VDCs (Figure 1). The staff of the Damak RCSC is composed of eight paramedics (health assistants) who are trained and experienced in recognizing features of envenoming, administering antivenoms and supportive therapy, and using mask-bag ventilation, including airway suction. The center is supported by the Nepalese Red Cross Society and includes a standby ambulance service to transport critically ill patients to referral hospitals.

Study design. The initial intention of the investigators was to randomize wards between intervention and control groups. The inclusion of non-intervention (control) wards was rejected by local health authorities and village leaders during preliminary discussions. Therefore, the intervention was implemented in all wards of the four VDCs. The intervention

* Address correspondence to François Chappuis, Division of International and Humanitarian Medicine, Geneva University Hospitals and University of Geneva, Geneva, Switzerland. E-mail: francois.chappuis@hcuge.ch

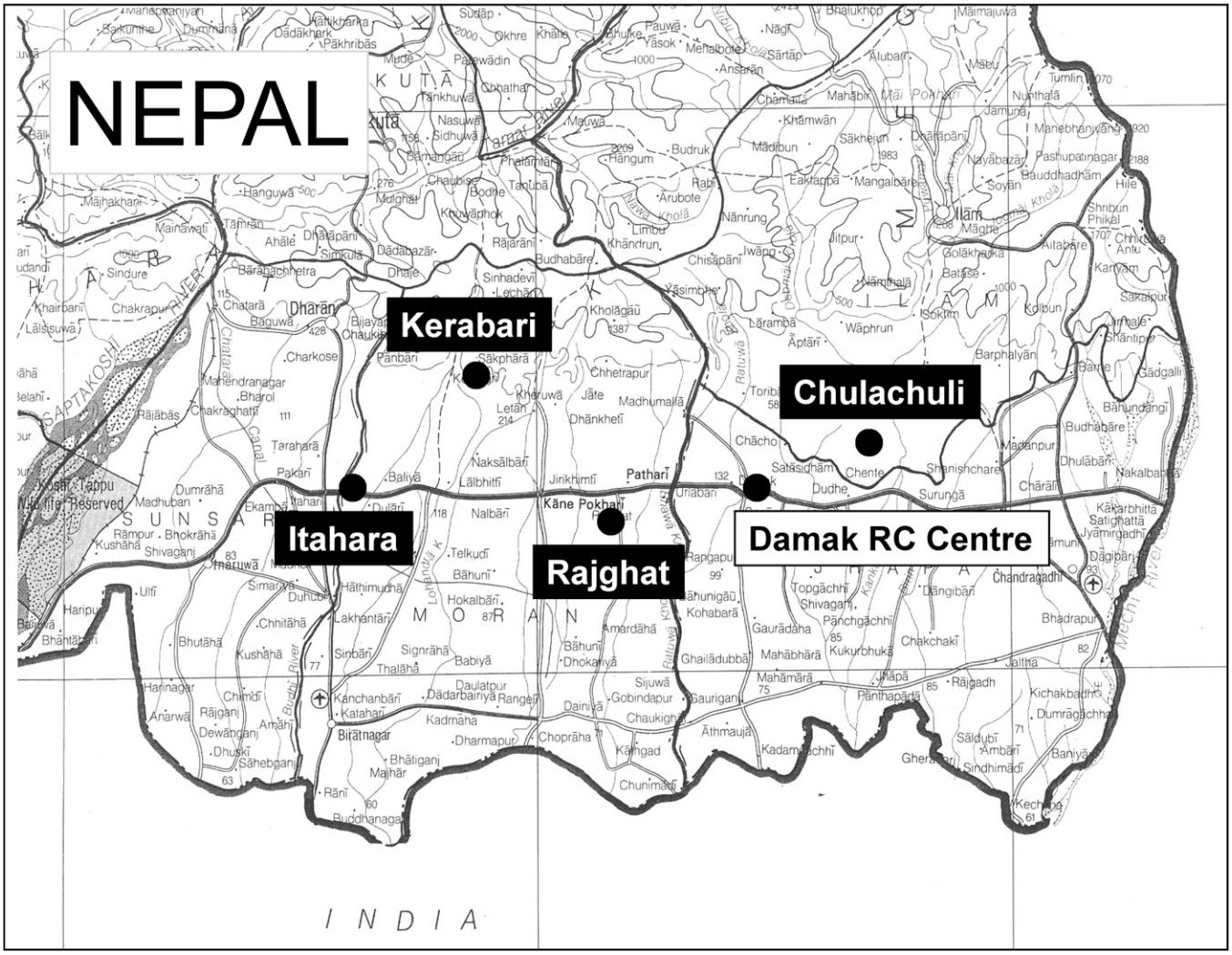

FIGURE 1. Map of the intervention area, southeastern Nepal. RC = Red Cross.

was composed of a motorcycle volunteer program and a community-based awareness program (Figure 2).

Motorcycle volunteer program. The program relied on a network of motorcycle owners who volunteered to transport victims of suspected or proven snake bite to the Damak RCSC as quickly as possible, and at any time of the day and the night. Motorcycle owners were initially identified by the villagers, and their names were cross-checked with the records of the district vehicle registration office. In March 2004, motorcycle owners living in the four VDCs were invited to a meeting during which the rapid transport intervention was described. Motorcycle owners were asked to participate in the program, and approximately 10 volunteers/VDC were enrolled. The only financial incentive for the motorcycle owner was the reimbursement of gasoline cost (US $5–7/transport). A duty roster was completed for the 2004 rainy

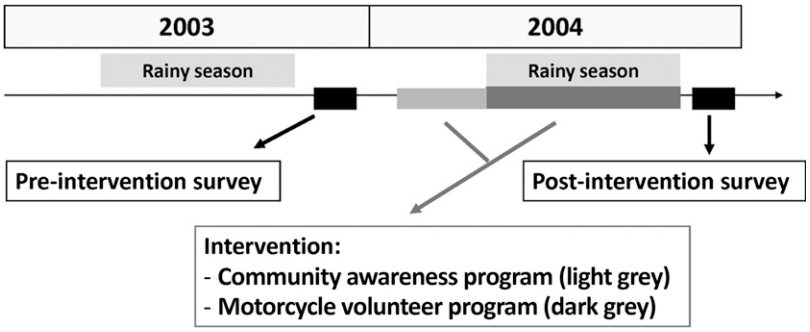

FIGURE 2. Schematic diagram of the intervention, southeastern Nepal.

FIGURE 3. Snake bite victim held firm on the motorcycle, southeastern Nepal. The victim does not wear a helmet to enable continuous assessment of his state of consciousness by the assistant pillion-rider during transport.

season, and the names and address of the motorcycle volunteers were displayed on various walls and boards in the VDCs.

The snake bite victim was held firmly during transport between the motorcycle driver and an assistant pillion-rider to prevent him or her from falling off the vehicle (Figure 3). Upon arrival at Damak RCSC, patients were clinically assessed and received an initial dose of 10 vials of polyvalent anti-snake venom serum (Haffkine Institute, Mumbai, India) if sign(s) of neurotoxicity were present. Patients with respiratory distress or arrest were assisted by oxygen and bag-mask-valve ventilation, and rapidly transferred by ambulance to the nearest referral hospital where intubation and assisted ventilation were available.

Community-based awareness program. Two to three snake bite awareness sessions were conducted in each of the four VDCs during January–March 2004. Political leaders, female health volunteers, community health workers, social workers, and traditional healers attended the sessions along with local persons. The importance of rapid transport of victims to the nearest snake bite treatment center was emphasized, and the motorcycle volunteer program was presented. The educational message used simple slogans such as "bitten by snake – catch motorcycle volunteers – reach Damak – save life!" in the local language. Sufficient time was also allocated to respond to questions related to the project or various other issues (e.g., primary prevention of snake bites). In addition, leaflets (n = 5,000) were distributed and banners and posters (n = 500) were pasted on walls and boards in the VDCs.

Assessment of efficacy. House-to-house surveys led by a team of 15 trained interviewers were conducted in the four VDCs before (November–December 2003) and after (November–December 2004) the intervention. The main objectives of the surveys were to determine the incidence of snake bites and numbers of deaths from these bites during the preceding rainy seasons: April–October 2003 (pre-intervention period) and April–October 2004 (intervention period). The same questionnaire was used in both surveys. Basic epidemiologic characteristics, occurrence and outcome of snake bites, first-aid methods used, and health-seeking behaviors were recorded.

To make up for the absence of control VDCs not benefiting from the intervention, we reviewed all records of patients admitted for snake bite at the Damak RCSC during the pre-intervention and intervention periods. The numbers of snake bites, envenomed bites, deaths, and individual basic demographic and epidemiologic data were retrieved from clinical files and compared between patients from the four intervention VDCs (intervention group) and from the other 43 VDCs (control group).

Ethical considerations. Informed consent was obtained from all villagers or their legal guardians for children < 16 years of age before inclusion in the study. The study was approved by the B. P. Koirala Institute of Health Sciences ethical review committee in August 2003.

Statistical analysis. Given the figures observed in the epidemiologic study conducted in nearly the same group of villages in 2002, we considered an annual snake bite incidence of 1,162/100,000 and an associated mortality rate of 162/100,000 in the pre-intervention period.[8] Assuming a 60,000 population sample before and after the intervention, we would be able to detect a 36% risk reduction in mortality.

Proportions were compared by using cross-tabulations, and chi-square tests and continuous variables were compared by using Student's *t*-test. The relative risk of death was calculated as the ratio between the proportion of death among victims of snake bites before (April–October 2003) and during (April–October 2004) the intervention. The relative risk reduction (RRR) was calculated by substracting the relative risk from 1. All statistical tests were two-tailed and had a significance level of $P < 0.05$. Statistical analyses were performed by using SPSS version 11.0 (SPSS, Inc., Chicago, IL) and confidence interval analysis for Windows (Microsoft, Redmond, WA).

RESULTS

A total of 11,177 (population = 60,759) and 10,916 (population = 59,383) households were visited during the pre-intervention (November–December 2003) and post-intervention (November–December 2004) surveys, respectively. Both surveys included > 95% of the total population. The reported snake bite incidence during April–October 2003 (pre-intervention period) was 502/100,000. The incidence of snake bites was significantly lower (315/100,000; RRR = 0.373, 95% confidence interval = 0.245–0.48, $P < 0001$) during April–October 2004 (intervention period). The reported case-fatality rate (CFR) of snake bites markedly decreased between the pre-intervention (32 deaths for 305 bites, CFR = 10.5%) and the intervention (1 death for 187 bites, CFR = 0.5%) periods (RRR = 0.949, 95% confidence interval = 0.695–0.999, $P < 0.0001$) (Table 1).

The demographic characteristics of snake bite victims and the circumstances of bites were comparable in the two surveyed periods (Table 2), with the exception that the proportion of females decreased from 52% to 41% in the intervention

TABLE 1

Reported number and incidence of snake bites and deaths before and during intervention programs in four village development committees, southeastern Nepal*

Characteristic	Pre-intervention period (April–October 2003)	Intervention period (April–October 2004)	RRR (95% CI)
No. snake bites	305	187	
Incidence of snake bites	502/100,000	315/100,000	0.373 (0.245–0.48)
No. deaths†	32	1	
Incidence of deaths†	53/100,000	2/100,000	0.968 (0.809–0.999)
Case-fatality rate	10.5%	0.5%	0.949 (0.695–0.999)

*RRR = relative risk reduction; CI = confidence interval.
†Deaths caused by snake bites only.

TABLE 2

Demographic characteristics, circumstances of bites and health-seeking behavior of victims of snake bites before and during intervention programs in four village development committees, southeastern Nepal

Characteristic	Pre-intervention period (April–October 2003) n = 305, no. (%)	Intervention period (April–October 2004) n = 187, no. (%)	P*
Mean (SD) age, years	30.1 (16.95)	29.2 (16.93)	0.6
Female sex	159 (52)	77 (41)	0.018
Village of origin			0.16
Itahara	122 (40)	94 (50.3)	
Chulachuli	87 (28.5)	46 (24.6)	
Rajghat	60 (19.7)	28 (15)	
Kerabari	36 (11.8)	19 (10.2)	
Type of house			0.37
Kuccha (mud walls)	105 (34)	57 (31)	
Other	200 (66)	130 (69)	
Location at time of bite			0.99
Inside	49 (16)	30 (16)	
Outside	256 (84)	157 (84)	
Activity at time of bite			0.95
Farming	69 (23)	39 (21)	
Walking	122 (40)	75 (40)	
Sleeping	24 (8)	14 (8)	
Other	90 (29)	59 (32)	
Time of bite			0.24
Morning	71 (23)	30 (16)	
Day	94 (31)	67 (36)	
Evening	111 (36)	69 (37)	
Night	29 (10)	21 (11)	
Site of bite			0.54
Upper limb	97 (32)	51 (27)	
Lower limb	205 (67)	135 (72)	
Other	2 (1)	1 (1)	
Use of tourniquet	255 (84)	161 (86)	0.46
First consultation at traditional healer	69 (23)	15 (8)	< 0.001
Transport by motorcycle	122 (40)	143 (77)	< 0.001

*Threshold for statistical significance was $P = 0.05$.

period ($P = 0.018$). Snake bite victims consulted traditional healers less often during the intervention period (8%) compared with the pre-intervention period (23%) ($P < 0.001$), and an increased proportion of victims (77% versus 55%) were transported directly to the Damak RCSC during the intervention period ($P < 0.001$). The use of motorcycle as a transport means increased from 36% (pre-intervention period) to 77% (intervention period) ($P < 0.001$). No snake bite victim died during transport, and no motorcycle accident was reported.

The review of Damak RCSC admission register and patient files showed that 714 and 692 snake bite victims were admitted during the pre-intervention and intervention periods, respectively (Table 3). The number of admitted victims from the four intervention VDCs significantly decreased from 188 (pre-intervention period) to 126 (intervention period) ($P < 0.001$), and a slight but significant increase (from 526 to 566) was observed in patients from control VDCs ($P < 0.001$). Numbers of envenomed bites and deaths in patients from control VDCs were similar in the pre-intervention and intervention periods. In contrast, numbers of victims from the four intervention VDCs with envenomed bites (n = 27 versus n = 8; $P = 0.026$) or deaths (n = 6 versus n = 0; $P = 0.085$) decreased between the pre-intervention and intervention periods. The use of a motorcycle to reach Damak RCSC from the four intervention VDCs sharply increased between pre-intervention and intervention periods (from 50.5% to 92.1%; $P < 0.001$), and it decreased for patients in control VDCs (from 39.7% to 29.9%; $P = 0.001$).

DISCUSSION

The implementation of a community-based awareness program and rapid transport of victims by motorcycle volunteers to a snake bite treatment center decreased the CFR of snake bites from 10.5% to 0.5% (RRR = 0.949) in four VDCs (total population = 62,127) in southeastern Nepal. The decreased CFR is likely to have resulted from 1) decreased consultation of traditional healers; 2) faster and more reliable access to motorcycles (the quickest mode of transport in rural areas); and 3) higher proportion of patients treated at the Damak RCSC, where health staff is trained and experienced in snakebite management, and where antivenom, ventilatory support (oxygen and bag-mask) and capacities to refer patients to tertiary hospital are available.

This finding confirms previous findings from a case–control study that analyzed risk factors for fatal outcome of snake bite in the same region, and showed an increased odds of survival in patients transported by motorcycle.[8] Previous studies investigated other strategies to reduce snake bite mortality, such as improvement of antivenom efficacy and safety,[15–17] and development of better first-aid methods and treatment protocols.[18–21] We demonstrated the efficacy of an innovative approach, i.e., promoting rapid transport of victims by motorcycle to a specialized snake bite center. This approach may be particularly relevant in areas in which elapid bites represent a substantial proportion of snake bite envenoming because envenomed elapid bites can rapidly progress to cause respiratory paralysis and death.

TABLE 3

Comparison of demographic characteristics and clinical outcome of patients admitted for snake bite at the Damak Red Cross Sub Center between pre-intervention and intervention periods, and between intervention and control village development committees, southeastern Nepal*

Characteristic	Intervention VDC			Control VDC		
	Pre-intervention period, no. (%)	Intervention period, no. (%)	P†	Pre-intervention period, no. (%)	Intervention period, no. (%)	P†
No. admissions	188 (26)	126 (18)	< 0.001	526 (74)	566 (82)	< 0.001
Mean (SD) age, years	28.0 (16.42)	29.1 (17.58)	0.55	28.4 (16.53)	29.6 (16.42)	0.23
Female sex	95 (50.5)	51 (40.5)	0.08	239 (45.4)	304 (53.7)	0.06
No. transported by motorcycle	95 (50.5)	116 (92.1)	< 0.001	209 (39.7)	169 (29.9)	0.001
No. deaths	6 (3.2)	0 (0)	0.085‡	10 (1.9)	6 (1.1)	0.25

*VDC = village development committee.
†Threshold for statistical significance was $P = 0.05$.
‡By Fisher's exact test.

Approximately 20% of snake bite victims were not transported by motorcycle and did not consult the Damak RCSC during the intervention period. The reasons for this finding are unclear. Because these persons had a favorable outcome, we can hypothesize that they were more likely to have rightly considered the snake as non-poisonous or the bite as benign (e.g., dry bites). Occasional non-availability of volunteers may also have played a role in this finding.

One of the main messages spread during the community awareness program was to avoid delay between the bite and transport by motorcycle to the treatment center. Consulting a traditional healer, which can result in wasting time, was associated with increased risk of dying of snake bite in Nepal.[8] The decreased proportion of victims who consulted traditional healers in the intervention VDCs likely results from the community awareness program and may have played a significant role in decreasing snake bite induced fatalities. Although first-aid measures such as tourniquets have been unanimously condemned, the efficacy of the pressure-immobilization method (PIM), which aims at slowing down the absorption of venom, remains a controversial issue.[22] The PIM is a method that firmly binds the bitten limb with a crepe bandage that starts distally around the toes or fingers and moves proximally to include a rigid splint. Crepe bandages rarely generates optimal pressures and the technique was found to be difficult to apply despite intense training of care providers.[23–25] In our opinion, wide implementation of PIM is unlikely to be currently feasible in rural Asia, and we therefore prefer to focus on simpler messages such as immediate transport of all snake bite victims to a treatment center.

The decrease in incidence of snake bites in the intervention VDCs was unexpected because the study intervention focused on decreasing the CFR, not the incidence. The hypothesis that the decrease resulted from an overall decrease of snake bite incidence in the region (e.g., caused by climatic factors) is unlikely because the analysis of admission registers and medical files from the Damak RCSC showed a significant increase of admissions from other VDCs during the intervention compared with the pre-intervention period. The decrease in snake bite incidence is likely to be caused by increased general awareness of the population about snake bites generated by the health education sessions and by other activities conducted during the study (e.g., surveys). Unfortunately, the use of primary prevention measures such as wearing boots or closed shoes, walking at night with a torch light or sleeping under bed nets, was not recorded during surveys.[26,27] It is interesting to note that the proportion of female victims of snake bite decreased during the intervention period, which may indicate better reception or understanding of educational messages among women.

Our study has several limitations, the main one being the absence of randomization. Therefore, the decreased CFR rate may have been influenced by factors unrelated to the intervention. One can hypothesize that the density of venomous snakes varied in the region between the two consecutive years. This hypothesis is unlikely because analysis of medical files from the Damak RCSC showed no significant changes in the numbers of envenomed bites and deaths in the control VDCs between pre-intervention and intervention periods. A decreased CFR could have resulted from improved case management of envenomed snake bites at Damak RCSC. This hypothesis is also unlikely because life-saving measures and indications for transfer to the referral hospital did not change at Damak RCSC during the study period.

Because the study was conducted in only one region of Nepal, the external validity of the findings is another study limitation. The efficacy of the rapid transport intervention is likely to be less pronounced in areas in which vipers represent a substantial proportion of venomous snakes because systemic clinical signs of viper bite envenoming occur more slowly than after elapid bites. The impact of the intervention may also be weaker in areas with lower density of motorcycle owners, longer distances to a treatment center, or lack of access to antivenoms or to ventilatory support.

The community awareness and motorcycle volunteer programs have been progressively extended to other VDCs around the Damak RCSC since 2005, and covered a population of > 300,000 inhabitants in 2011. The project is now financially entirely supported by the Nepalese Red Cross. This initiative has also been implemented in other parts of eastern Terai. We are convinced that this intervention should be replicated and its efficacy evaluated in other parts of southern Asia and elsewhere (e.g., Africa), where available transports are limited and where morbidity and mortality from snake bites are associated with increased bite-to-hospital time.[28,29] Cost-effectiveness analysis of the intervention would also help policy makers. In addition, other types of medical emergencies may also benefit from a community-based approach involving motorcycle volunteers. For example, in a study conducted in Malawi, the use of motorcycle ambulances reduced the delay in referring women with obstetric complications from rural health centers to the district hospital, and was cheaper than car ambulances.[30]

The public health intervention described should be integrated in a more global strategy aiming at reducing the incidence and mortality from snake bites in the countries most affected by this neglected condition. Other urgent priorities are to 1) improve the safety and accessibility of antivenoms, 2) develop evidence-based therapeutic regimens, 3) develop point-of-care diagnostic tools able to differentiate snake species, 4) improve knowledge of care providers and provide training for life-saving measures such as ventilatory support, and 5) increase donor commitment for research and control activities.

Received December 13, 2012. Accepted for publication March 13, 2013.

Published online April 8, 2013.

Acknowledgments: We thank the staff of the Damak Red Cross Sub Centre and political leaders, female health volunteers, community health workers, social workers, and traditional healers from Chulachuli, Kerabari, Itahara, and Rajghat for facilitating the conduct of the intervention; and all motorcycle volunteers for their commitment to transport victims of snake bites at any time of day and night during and after the study period.

Financial support: The study was supported by grants from the Geneva University Hospitals and the Sonisca Foundation.

Authors' addresses: Sanjib K. Sharma, Department of Medicine, B. P. Koirala Institute of Health Sciences, Dharan, Nepal, E-mail: drsanjib@yahoo.com. Patrick Bovier, Lausanne, Switzerland, E-mail: patrick.bovier@post.harvard.edu. Nilambar Jha, School of Public Health and Community Medicine, B. P. Koirala Institute of Health Sciences, Dharan, Nepal, E-mail: jhanilambar60@gmail.com. Emilie Alirol, Louis Loutan, and François Chappuis, Division of International and Humanitarian Medicine, Geneva University Hospitals and University of Geneva, Switzerland, E-mails: emilie.alirol@hcuge.ch, louis.loutan@hcuge.ch, and francois.chappuis@hcuge.ch.

REFERENCES

1. World Health Organization, 1987. Baseline epidemiological study on snake-bite treatment and management. *Wkly Epidemiol Rec 42:* 319–320.
2. Chippaux JP, 1998. Snake-bites: appraisal of the global situation. *Bull World Health Organ 76:* 515–524.
3. Kasturiratne A, Wickremasinghe AR, de Silva N, Gunawardena NK, Pathmeswaran A, Premaratna R, Savioli L, Lalloo DG, de Silva HJ, 2008. The global burden of snakebite: a literature analysis and modelling based on regional estimates of envenoming and deaths. *PLoS Med 5:* e218.
4. Alirol E, Sharma SK, Bawaskar HS, Kuch U, Chappuis F, 2010. Snake bite in south Asia: a review. *PLoS Negl Trop Dis 4:* e603.
5. Mohapatra B, Warrell DA, Suraweera W, Bhatia P, Dhingra N, Jotkar RM, Rodriguez PS, Mishra K, Whitaker R, Jha P, 2011. Snakebite mortality in India: a nationally representative mortality survey. *PLoS Negl Trop Dis 5:* e1018.
6. Sharma SK, Khanal B, Pokhrel P, Khan A, Koirala S, 2003. Snakebite: reappraisal of the situation in eastern Nepal. *Toxicon 41:* 285–289.
7. Pandey DP, 2007. Epidemiology of snakebites based on field survey in Chitwan and Nawalparasi districts, Nepal. *J Med Toxicol 3:* 164–168.
8. Sharma SK, Chappuis F, Jha N, Bovier PA, Loutan L, Koirala S, 2004. Impact of snake bites and determinants of fatal outcomes in southeastern Nepal. *Am J Trop Med Hyg 71:* 234–238.
9. Hansdak SG, Lallar KS, Pokharel P, Shyangwa P, Karki P, Koirala S, 1998. A clinico-epidemiological study of snake bite in Nepal. *Trop Doct 28:* 223–226.
10. Heap BJ, Cowan GO, 1991. The epidemiology of snake bite presenting to British Military Hospital Dharan during 1989. *J R Army Med Corps 137:* 123–125.
11. Warrell DA, 1995. Clinical toxicology of snake bites in Asia. White MA, ed. *Handbook of Clinical Toxicology of Animal Venoms and Poisons*. Boca Raton, FL: CRC Press, 493–588.
12. Warrell DA, 2009. Venomous and poisonous animals. Cook GC, Zumla AI, eds. *Manson's Tropical Diseases*, 22nd edition. London: Academic Press, 557–581.
13. Wall F, 1921. *Ophidia taprobanica* or the snakes of Ceylon. Cottle HR, ed. Colombo, Sri Lanka: Governmental Press Ceylon, 529–546.
14. Anonymous, 2002. *District Demographic Profile of Nepal*. Kathmandu, Nepal: Informal Sector Research and Study Center.
15. Otero R, Gutierrez JM, Rojas G, Nuñez V, Diaz A, Miranda E, Uribe AF, Silva JF, Ospina JG, Medina Y, Toro MF, Garcia ME, Leon G, Garcia M, Lizano S, De la Torre J, Marquez J, Mena Y, Gonzales N, Arenas LC, Puzon A, Blanco N, Sierra A, Espinal ME, Arboleda M, Jimenez JC, Ramirez P, Diaz M, Guzman MC, Barros J, Henao S, Ramirez A, Macea U, Lozano R, 1999. A randomized blinded clinical trial of two antivenoms, prepared by caprylic acid or ammonium sulphate fractionation of IgG, in *Bothrops* and *Porthidium* snake bites in Colombia: correlation between safety and biochemical characteristics of antivenoms. *Toxicon 37:* 895–908.
16. Otero R, Leon G, Gutierrez JM, Rojas G, Toro MF, Barona J, Rodriguez V, Diaz A, Nuñez V, Quintana JC, Ayala S, Mosquera D, Conrado LL, Fernandez D, Arroyo Y, Paniagua CA, Lopez M, Ospina CE, Alzate C, Fernandez J, Meza JJ, Silva JF, Ramirez P, Fabra PE, Ramirez E, Cordoba E, Arrieta AB, Warrell DA, Theakston DG, 2006. Efficacy and safety of two whole IgG polyvalent antivenoms, refined by caprylic acid fractionation with or without beta-propiolactone, in the treatment of *Bothrops asper* bites in Colombia. *Trans R Soc Trop Med Hyg 100:* 1173–1182.
17. Smalligan R, Cole J, Brito N, Laing GD, Mertz BL, Manock S, Maudlin J, Quist B, Holland G, Nelson S, Lalloo DG, Rivadeneira G, Barragan ME, Dolley D, Eddleston M, Warrell DA, Theakston RD, 2004. Crotaline snake bite in the Ecuadorian Amazon: randomised double blind comparative trial of three South American polyspecific antivenoms. *BMJ 329:* 1129.
18. Simpson ID, Norris RL, 2007. Snakes of medical importance in India: is the concept of the "Big 4" still relevant and useful? *Wilderness Environ Med 18:* 2–9.
19. Warrell DA, 1999. WHO guidelines for the clinical management of snake bites in the South East Asia region. *SE Asian J Trop Med Publ Health 30 (Suppl):* 1–83.
20. Sutherland SK, Coulter AR, Harris RD, 1979. Rationalisation of first-aid measures for elapid snakebite. *Lancet 1:* 183–185.
21. Boyd JJ, Agazzi G, Svajda D, Morgan AJ, Ferrandis S, Norris RL, 2007. Venomous snakebite in mountainous terrain: prevention and management. *Wilderness Environ Med 18:* 190–202.
22. Pe T, Mya S, Myint AA, Aung NN, Kyu KA, Oo T, 2000. Field trial of local compression immobilization first-aid technique in Russel's viper (*Daboia Russelii siamensis*) bite patients. *Southeast Asian J Trop Med Public Health 31:* 346–348.
23. Canale E, Isbister GK, Currie BJ, 2009. Investigating pressure bandaging for snakebite in a simulated setting: bandage type, training and the effect of transport. *Emerg Med Australas 21:* 184–190.
24. Howarth DM, Southee AE, Whyte IM, 1994. Lymphatic flow rates and first-aid in simulated peripheral snake or spider envenomation. *Med J Aust 161:* 695–700.
25. Simpson ID, Tanwar PD, Andrade C, Kochar DK, Norris RL, 2008. The Ebbinghaus retention curve: training does not increase the ability to apply pressure immobilisation in simulated snake bite; implications for snake bite first aid in the developing world. *Trans R Soc Trop Med Hyg 102:* 451–459.
26. Bawaskar HS, Bawaskar PH, 2010. Snake bite: simple steps to prevention and reduction of morbidity. *Lancet 375:* 805.
27. Chappuis F, Sharma SK, Jha N, Loutan L, Bovier PA, 2007. Protection against snake bites by sleeping under a bed net in southeastern Nepal. *Am J Trop Med Hyg 77:* 197–199.
28. Bawaskar HS, Bawaskar PH, 2004. Envenoming by the common krait (*Bungarus caeruleus*) and Asian cobra (*Naja naja*): clinical manifestations and their management in a rural setting. *Wilderness Environ Med 15:* 257–266.
29. Ogunfowokan O, Jacob DA, Livinus OL, 2011. Relationship between bite-to-hospital time and morbidity in victims of carpet viper bite in north-central Nigeria. *West Afr J Med 30:* 348–353.
30. Hofman JJ, Dzimadzi C, Lungu K, Ratsma EY, Hussein J, 2008. Motorcycle ambulances for referral of obstetric emergencies in rural Malawi: do they reduce delay and what do they cost? *Int J Gynaecol Obstet 102:* 191–197.